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Full-Scale Fire Testing of Seat Component Materials

October 1993

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16. Abstract

Full-scale fire testing was conducted in a furnished aircraft cabin to compare a currently used thermoplastic material and a new thermoplastic material with low heat and smoke release characteristics used in forming seat components. This testing was conducted due to questions concerning the exemption of seat components from the heat release and smoke requirement mandated for certain large surface area components in the aircraft fuselage. Results of the full-scale testing showed no significant difference in temperatures, smoke levels, or oxygen depletion between the two materials. While carbon monoxide and carbon dioxide emissions were slightly higher with the currently used material, it cannot be concluded that this material was the cause. Based on the overall data, it appears that the small amount of seat component material is not significantly contributing to increased fire hazards.

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EXECUTIVE SUMMARY

In August of 1990, the Federal Aviation Administration (FAA) mandated a low heat release and smoke requirement for certain large surface area components in the aircraft fuselage. Components which do not require this testing are the thermoplastics on the passenger seats. Questions concerning their exemption from this regulation prompted the FAA to conduct full-scale fire tests in a furnished aircraft cabin to address this matter. A currently used thermoplastic and new thermoplastic material with low heat and smoke release characteristics were cut into pieces representing armrests, foodtrays, and endbays (assemblies that include aisle armrests including trim) and attached to frames representing passenger seats. Results of full-scale fire testing showed no significant difference in temperatures, smoke levels, or oxygen depletion between the two materials. While carbon monoxide and carbon dioxide emissions were somewhat higher with the currently used thermoplastic material, it cannot be concluded that this material was the cause. Based on the overall data, it appears that the small amount of seat component material does not significantly contribute to increased fire hazards.

INTRODUCTION

PURPOSE.

The objective of this test activity was to compare a thermoplastic seat component material which passes the vertical flammability test with a new thermoplastic with low heat and smoke characteristics. These materials were evaluated with respect to their contribution to overall cabin fire hazards under full-scale postcrash fire conditions.

BACKGROUND.

In August of 1990, the Federal Aviation Administration (FAA) mandated a heat release and smoke requirement for certain large surface area components in compartments occupied by the crew or passengers. This regulation applies to aircraft with passenger capacities of 20 or more. Among the materials that must meet these requirements are interior ceiling and wall panels, partitions, and outer surfaces of galleys. One set of components which do not require this testing are the thermoplastic passenger seat parts. These include armrests, endbays, and foodtrays. In the United States, acrylonitrile-butadiene-styrene/polyvinyl chloride (ABS/PVC) thermoplastic sheet is the most commonly used material to mold these parts. Among the desirable traits of this material are very high impact strength, high tensile strength, formability, stiffness, and light weight. Currently, the only flammability regulation the FAA imposes on seat component materials is the 12-second vertical flammability test specified in FAR 25.853 (a) - Appendix F Part 1 (a) (ii). However, questions concerning these components and their exemption from the heat release and smoke requirements have recently come into focus. In order to address these questions, the FAA ran full-scale comparative fire tests in order to assess the contribution of ABS/PVC seat components versus a new material which meets the new requirements.

DISCUSSION

TEST MATERIALS.

A currently used ABS/PVC thermoplastic material and a new thermoplastic material (polyetherketoneketone) (PEKK) surfaced with Tedlar™ polyvinyl fluoride (PVF) film were selected as the two test materials. The ABS/PVC material was supplied by the manufacturer in sheets, 0.047 inch in thickness. This thickness was chosen since it is a commonly used size for foodtrays and armrests on coach class seats. The new material was supplied in sheets, 0.040 inch in thickness (this material is not available in 0.047 inch thickness).

SMALL-SCALE TESTING.

Prior to full-scale testing, both materials were subjected to 12-second vertical Bunsen burner testing, heat release testing using the Ohio State University (OSU) rate of heat release apparatus as specified in FAR 25.853 (c) - Appendix F Part IV, and smoke emission testing using the National Bureau of Standards smoke chamber as specified in FAR 25.853 (c) - Appendix F Part V. Test results are given in table 1.

TABLE 1

SMALL SCALE TEST RESULTS

12 - SECOND VERTICAL TESTING

Average Value - 3 Specimens

ABS/PVC	New Material
burn length 1.25 inches	burn length 1.1 inches
after flame time 0	after flame time 0
drip flaming time 0	drip flaming time 0

OSU HEAT RELEASE DATA

One test due to high number	Average value of 3 specimens
total heat release 102.97 kW. min`/sq.m	total heat 26.1 kW.min/sq.m
peak heat release rate 149.77 kW/sq.m	peak heat release rate 43.1 kW/sq.m

NBS SMOKE TEST DATA

One test due to high number	Average value of 3 specimens
D_S at 4 min. 775.8	D_S at 4 min. 5.0

SMALL-SCALE TEST RESULTS.

The test data clearly indicate that both materials pass the 12-second vertical test. The burn lengths of both are significantly less than the 8-inch maximum allowed. Moreover, neither material continued to burn following removal of the flame or had flaming drips. The OSU results show that the ABS/PVC values far exceeded the 65/65 total heat release and peak heat release values allowed. As stated in the test results, only one sample was run due to the high numbers. The average values of three specimens of the new material were below the 65/65 limits. NBS smoke testing showed that the ABS/PVC material significantly surpassed the specific optical density (Ds) maximum of 200 after 4 minutes. Here again, only one sample was run. The average Ds value of three specimens of the new material was well below the 200 maximum.

FULL-SCALE TESTING - TEST ARTICLE.

Testing was conducted in a modified DC-10 fuselage (hereafter referred to as the Technical Center 10 or TC-10). The cabin was furnished with actual stowbins and ceiling panels that meet the 65/65 heat release and smoke requirement. The sidewall panels were Boeing 747 surplus panels which do not pass these tests. The carpeting was a 90/10 wool/nylon blend which meets the 12-second vertical test. Carpet does not require heat release or smoke testing. All tests were 5 minutes in duration. The fire scenario used a standard 8- by 10-foot pan fire adjacent to a type A door opening; 55 gallons of JP-4 fuel were used to create the pan fire. The fire was drawn into the fuselage with the aid of a fan mounted at the forward bulkhead (nose). The fan exhausted at a rate no greater than 5000 cubic feet per minute. The TC-10 test article was fully fire hardened and instrumented with thermocouple trees, smoke meters, gas sampling stations/gas analyzers, calorimeters, and photographic and video coverage (figure 1). A description of the instrumentation follows:

Thermocouple Trees. Seven thermocouple trees continuously measured the temperature throughout the cabin. The trees were located at 40, 220, 400, 590, 750, 940, and 1180 inches from the forward most point of the test article from 1 foot above the floor to 8 feet above the floor. The 8-foot location was just under the ceiling level.

Smoke Meters. Smoke meter stations were located at 80, 340, 570, and 1320 inches from the nose. Each station contained three smoke meters positioned at 18, 42, and 66 inches from the floor level. The smoke meters consisted of a collimated light source and photocell separated by 1 foot.

Gas Analysis. Continuous gas sampling stations used to measure carbon monoxide, carbon dioxide, and oxygen were located at 60 and 530 inches from the nose. Each station had two intakes at heights of 42 and 66 inches from the floor.

Calorimeters. Calorimeters were used to measure the heat flux at four locations: 80, 590, 940, and 1320 inches. The transducers were all mounted at a height of 42 inches. At stations 80 and 590, the transducers were facing aft; at station 1320, the transducer was facing forward. The transducer located at station 940 was facing directly toward the fire door.

PASSENGER SEAT PREPARATION.

Thirty-nine frames representing passenger seats were fabricated using mild steel angle. They were arranged in the following configuration: Three rows were centered about the fire, each containing a double, quad, and triple seats. Two additional rows were located forward and aft of the three centered rows consisting of a double and quad seat. Refer to figure 2. Both materials supplied in sheets were cut into pieces representing foodtrays, armrests, and endbays. The dimensions are as follows:

armrest	8 by 22 inches
foodtray	16 by 22 inches
endbay	11 by 22 inches

Actual thermoplastic seat components are curved and molded parts. Since flat sheet was used to simulate seat components in this test, the dimensions were chosen to approximate the plane area of a component if it were not formed. Both the seat and back urethane cushions were wrapped with a fire blocking layer in compliance with FAR 25.853 (b), Appendix F Part II and dress covers. A two-seat grouping with and without cushions is shown in figure 3.

TEST RESULTS.

Figures 4, 5, 6, and 7 show temperature profiles at thermocouple stations 40, 590, 940, and 1180. The temperatures are compared at the 1-, 4-, and 8-foot locations. The data clearly show insignificant differences. It is apparent that the ABS/PVC thermoplastic is not contributing heat to the extent that overall temperatures are higher than the contribution made by the new material. The comparison of smoke levels at stations 80, 570, and 1320 indicates no significant change in visibility between the two materials (figures 8 through 10). Oxygen depletion curves are shown in figures 11 and 12. Again, no significant differences between the two materials can be seen. Carbon monoxide and carbon dioxide profiles are shown in figures 13 through 16. The emission of both gases is higher for the test that incorporated the ABS/PVC material in comparison to the test with the new thermoplastic. This can be seen at both stations and both heights.

SUMMARY

Based on the results of the temperatures, smoke levels, and oxygen depletion analysis, no significant differences were observed when comparing ABS/PVC thermoplastic and the new material for their contribution to overall fire hazards. While there was a higher emission of carbon monoxide and carbon dioxide during the test with the ABS/PVC, it is not conclusive that this material accounted for higher gas emission. Overall, the data would suggest that the small amount of thermoplastic seat component material compared to the total amount of materials inside the fuselage is not contributing sufficient flammability by-products to significantly increase the fire risk.

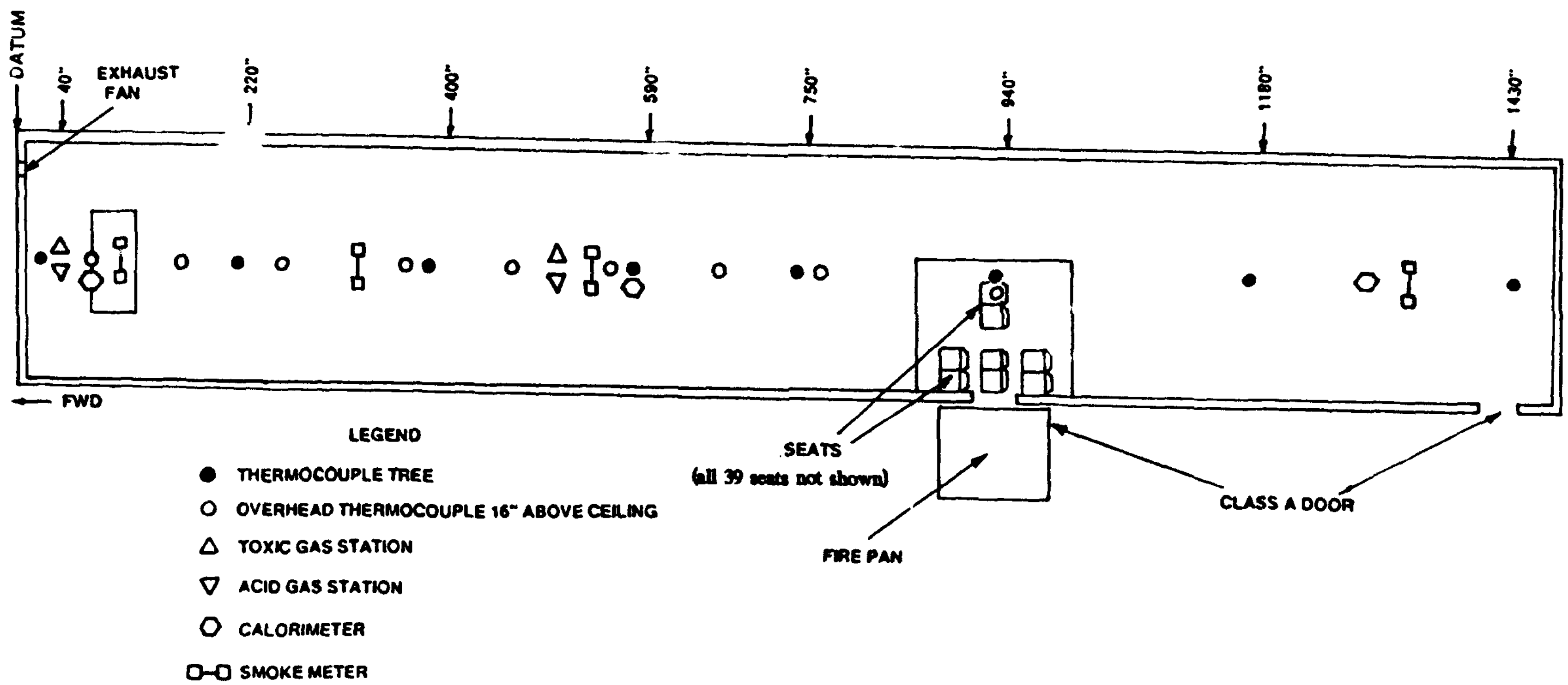

FIGURE 1. TC-10 CONFIGURATION

SEATING ARRANGEMENT FOR
TC-10 SEAT COMPONENT TESTS

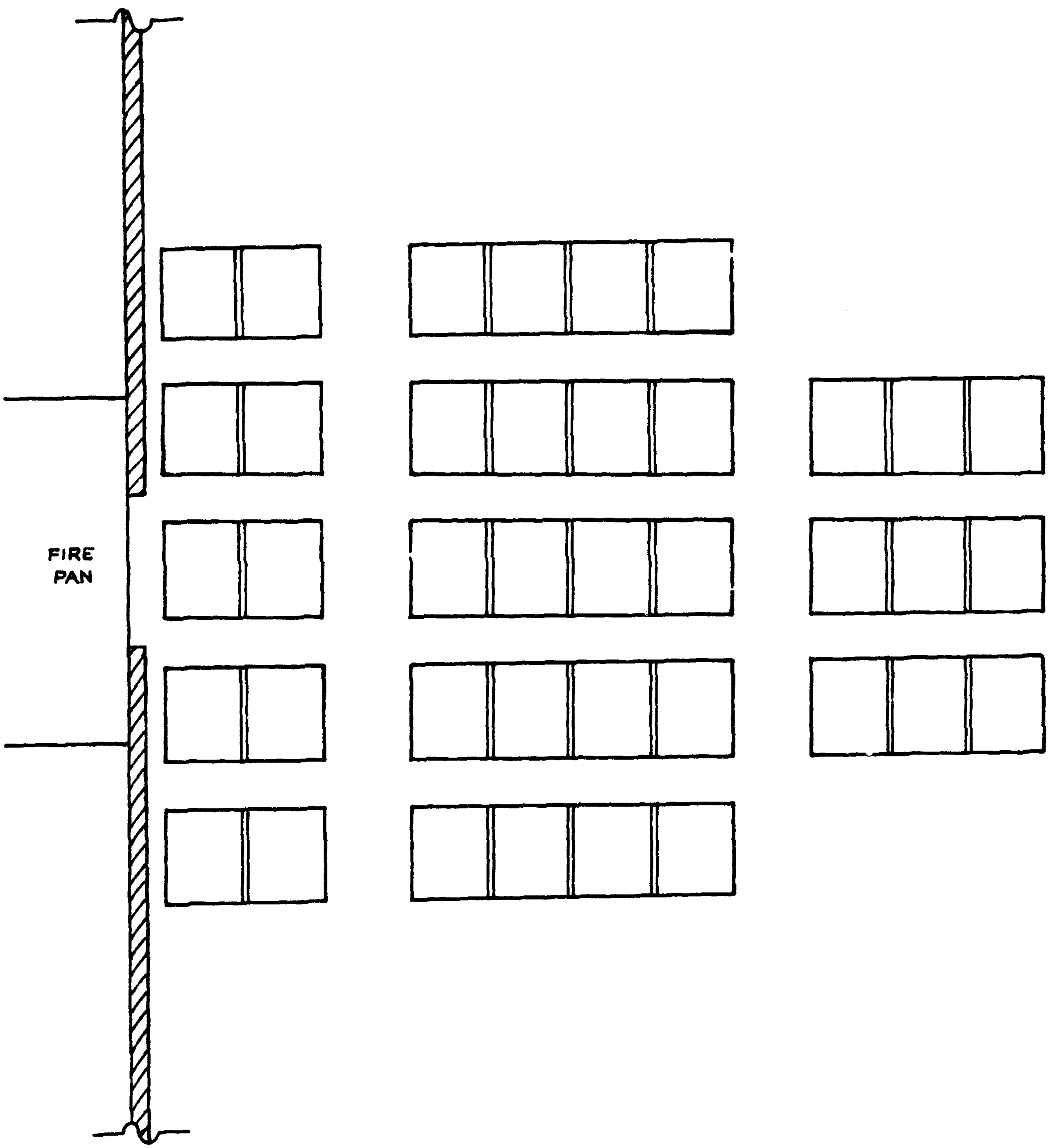

FIGURE 2. SEAT CONFIGURATION

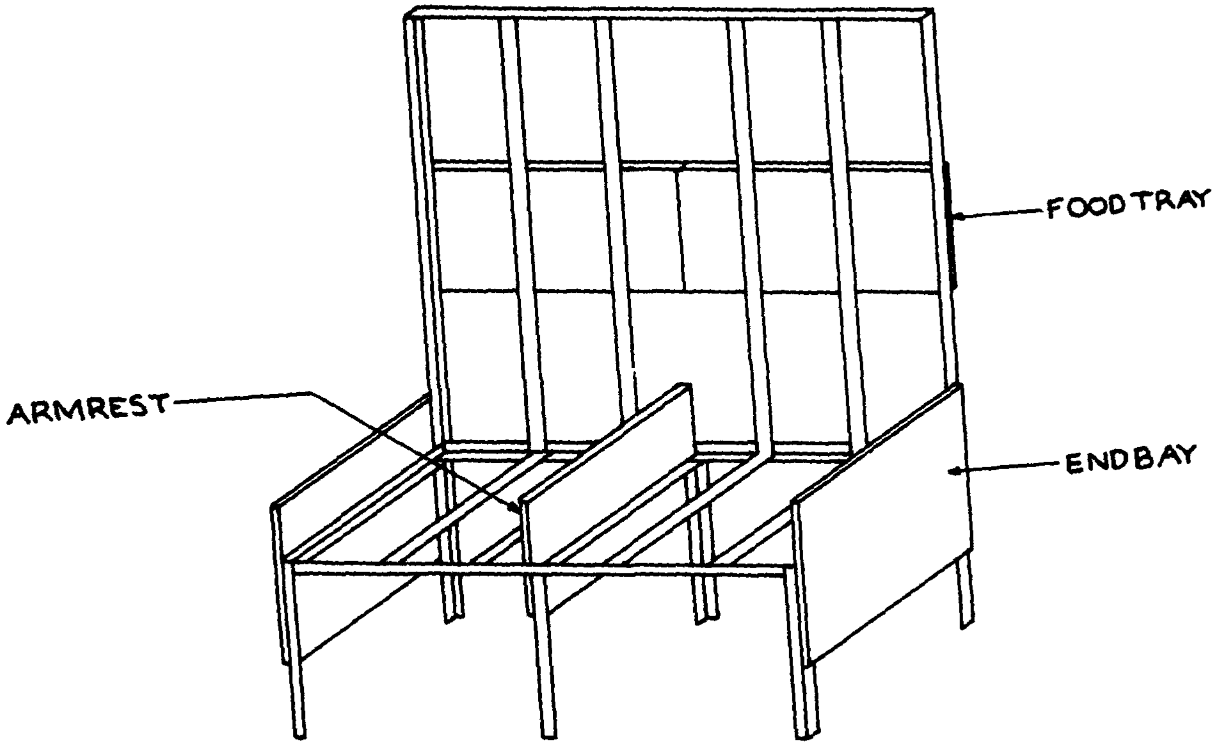

FIGURE 3-A. TWO-SEAT GROUPING WITH SHROUDS

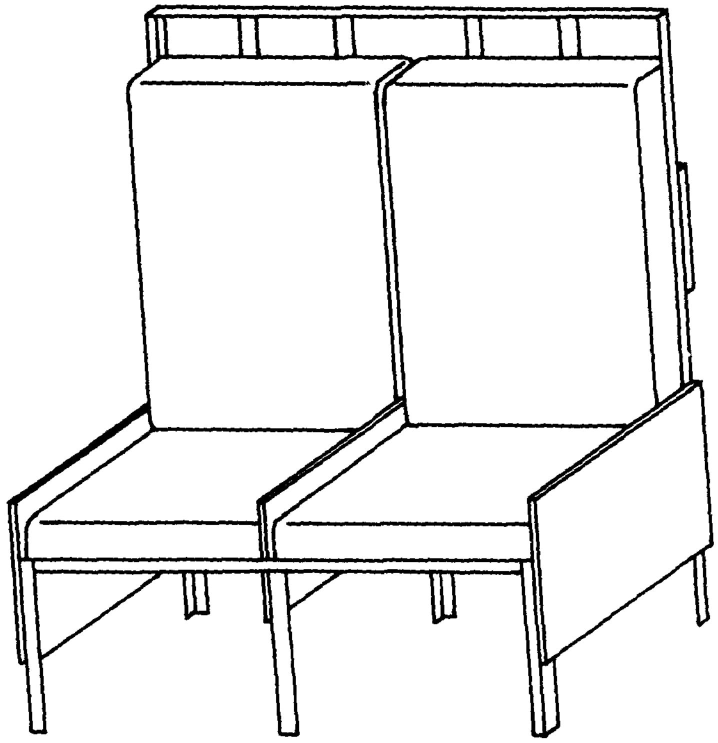

FIGURE 3-B. TWO-SEAT GROUPING WITH CUSHIONS AND SHROUDS

FIGURE 3. TWO-SEAT GROUPINGS

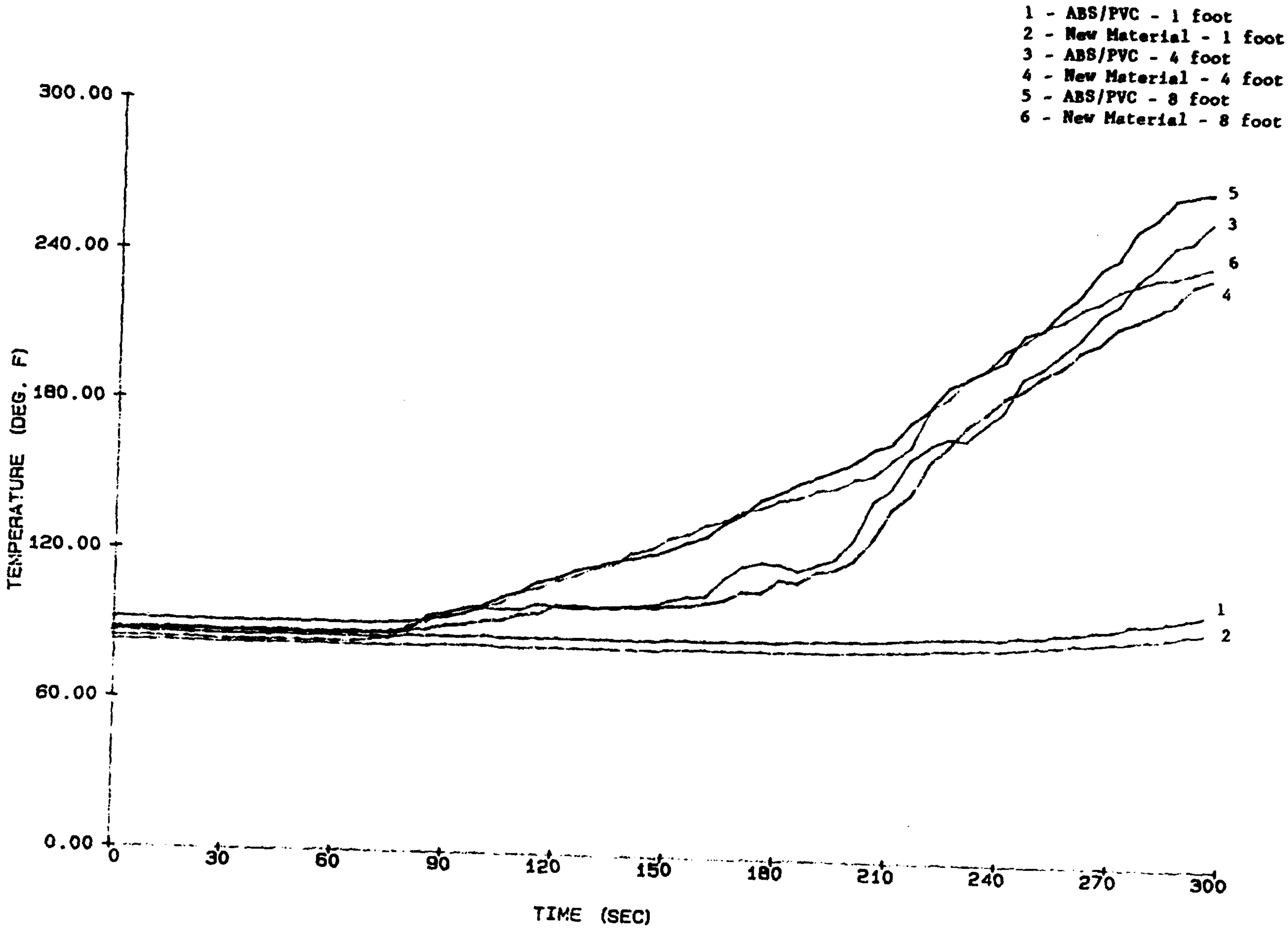

FIGURE 4. THERMOCOUPLE STATION 40

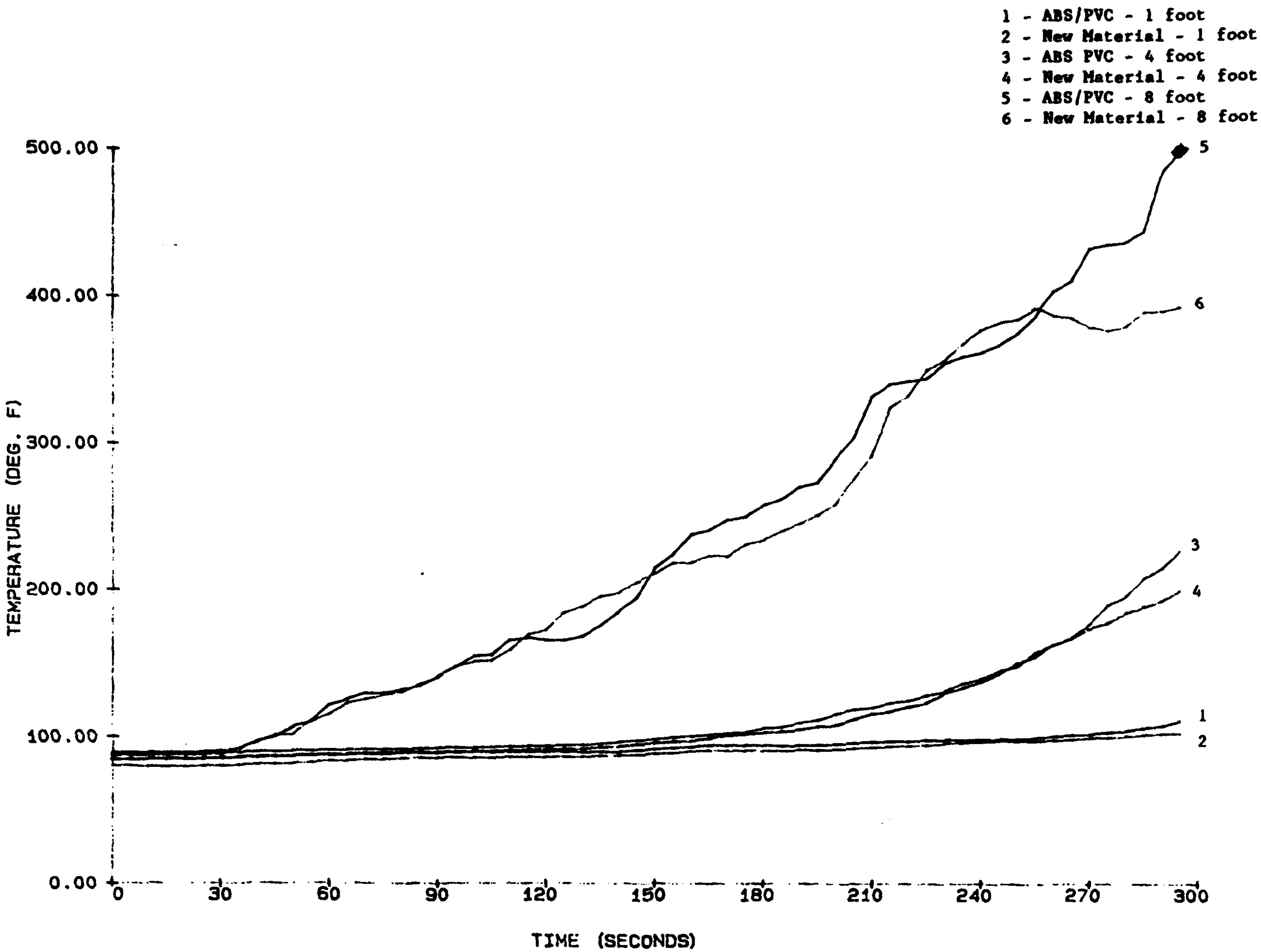

FIGURE 5. THERMOCOUPLE STATION 590

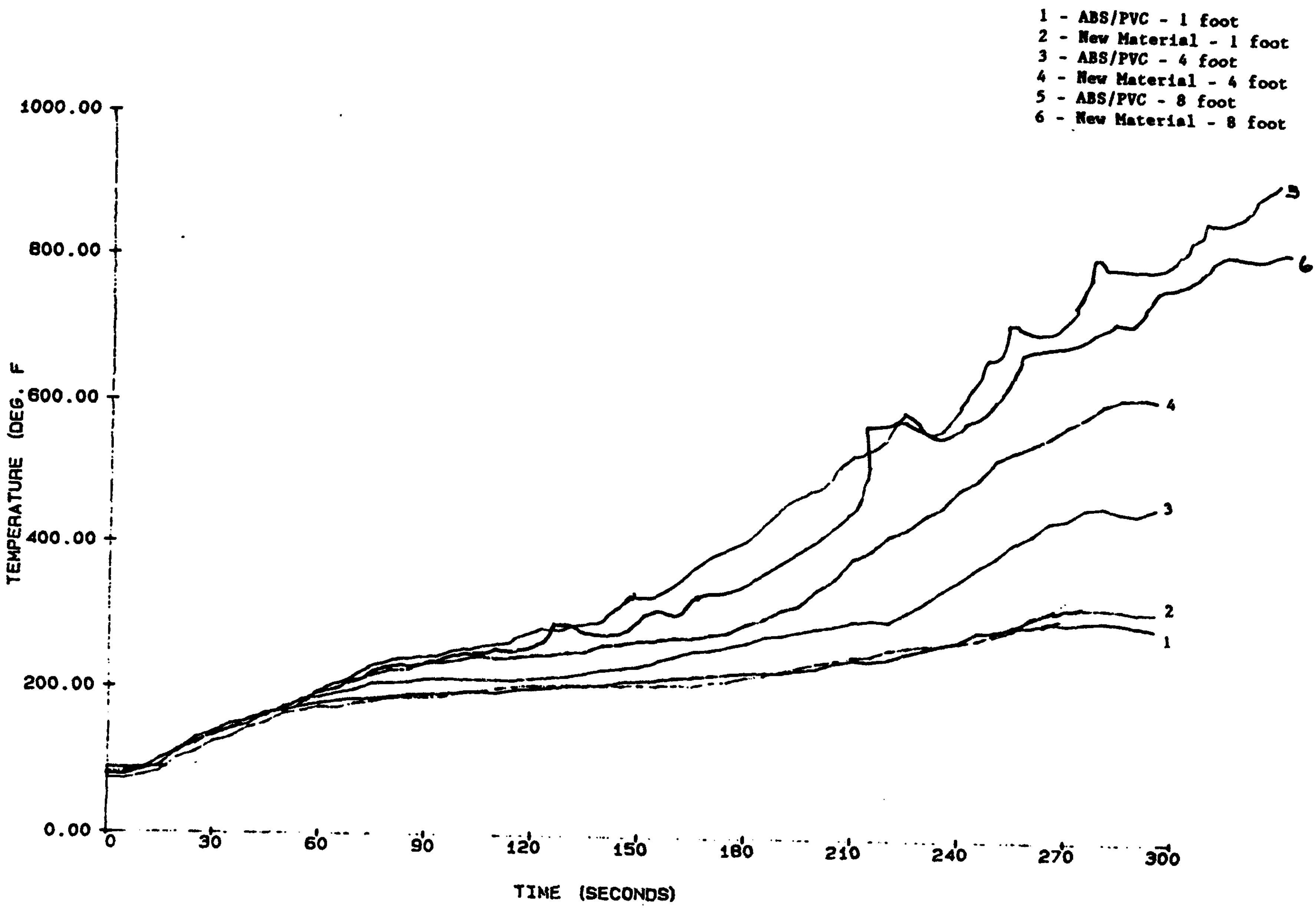

FIGURE 6. THERMOCOUPLE STATION 940

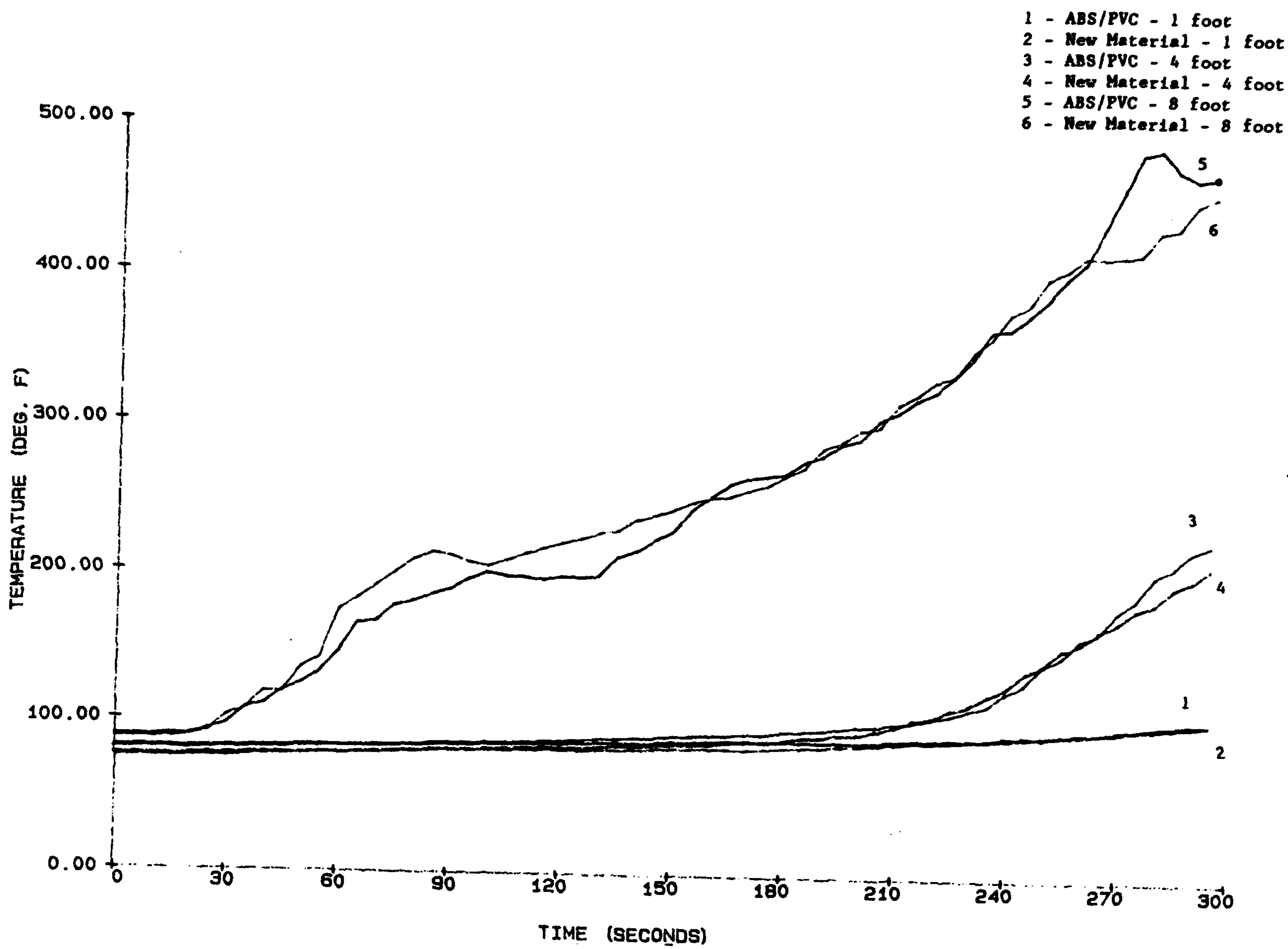

FIGURE 7. THERMOCOUPLE STATION 1180

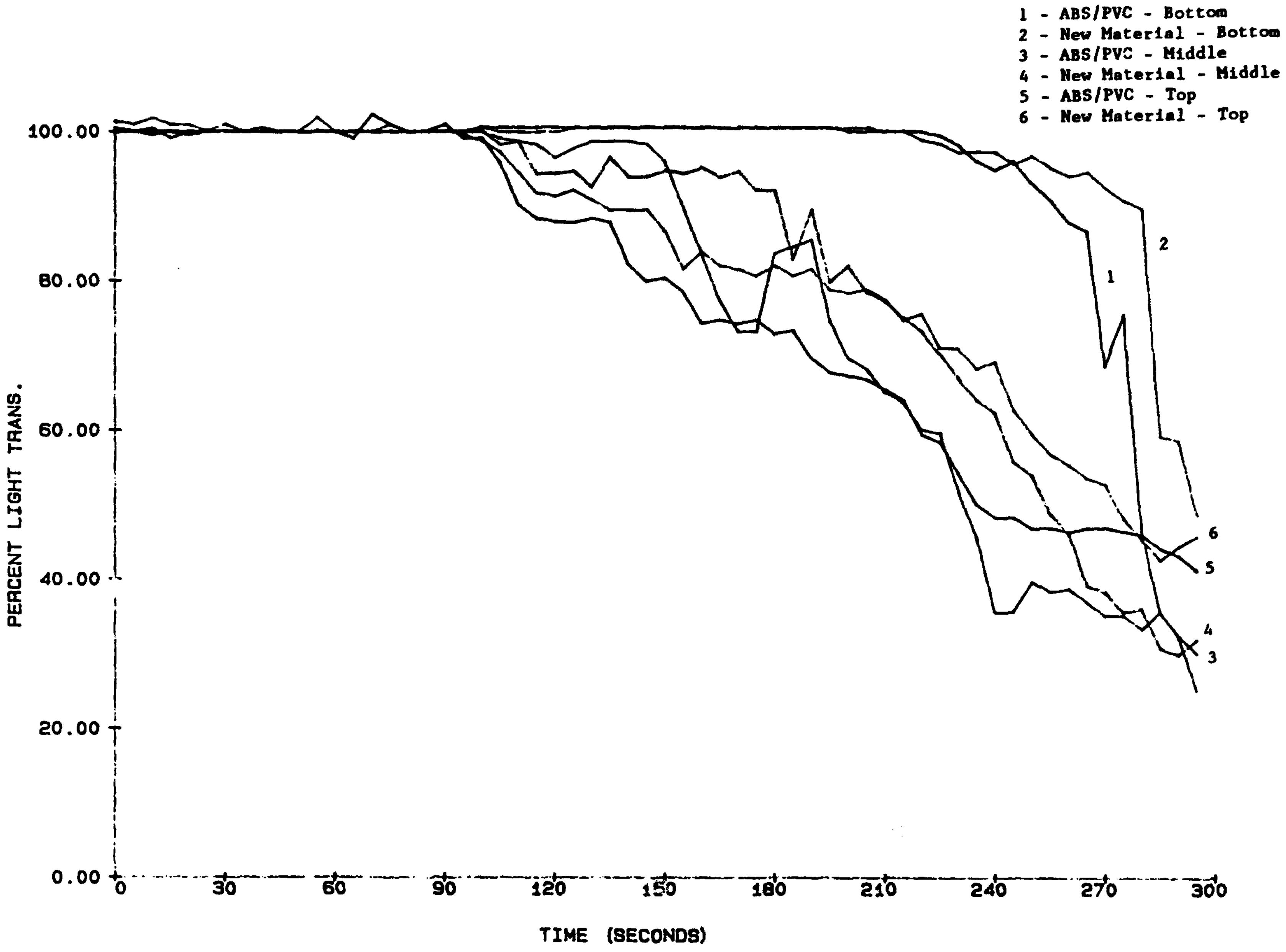

FIGURE 8. SMOKE STATION 80

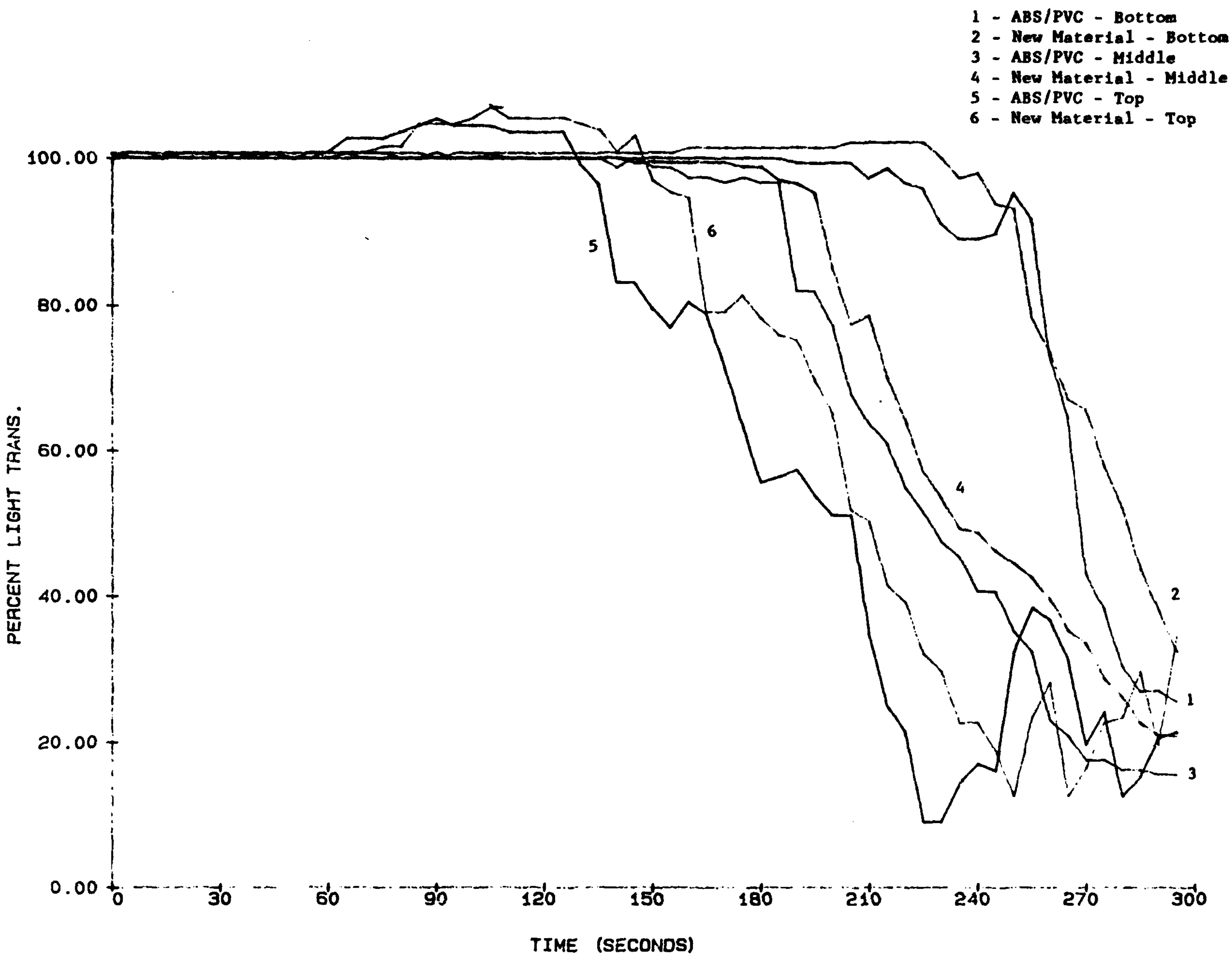

FIGURE 9. SMOKE STATION 570

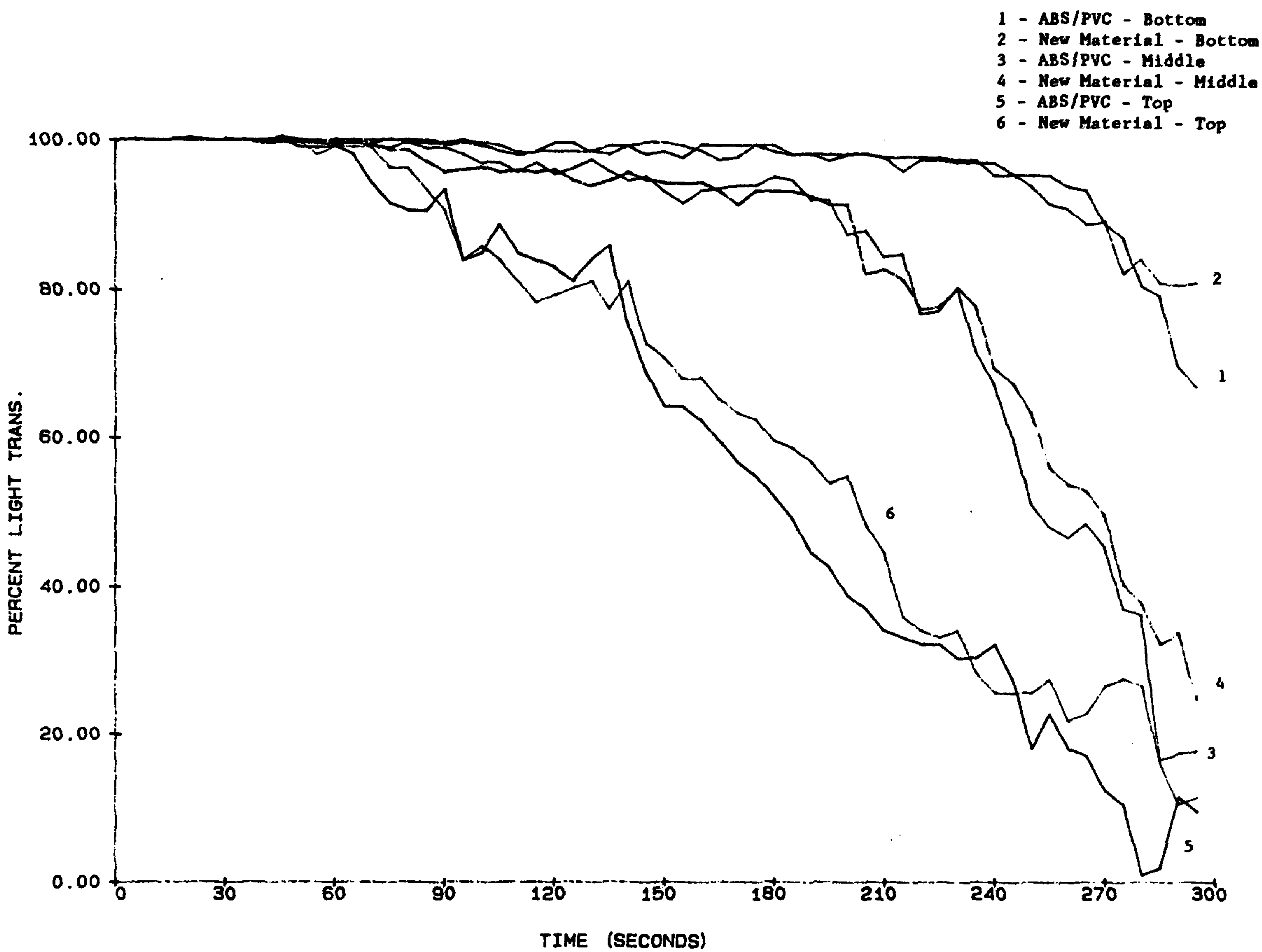

FIGURE 10. SMOKE STATION 1320

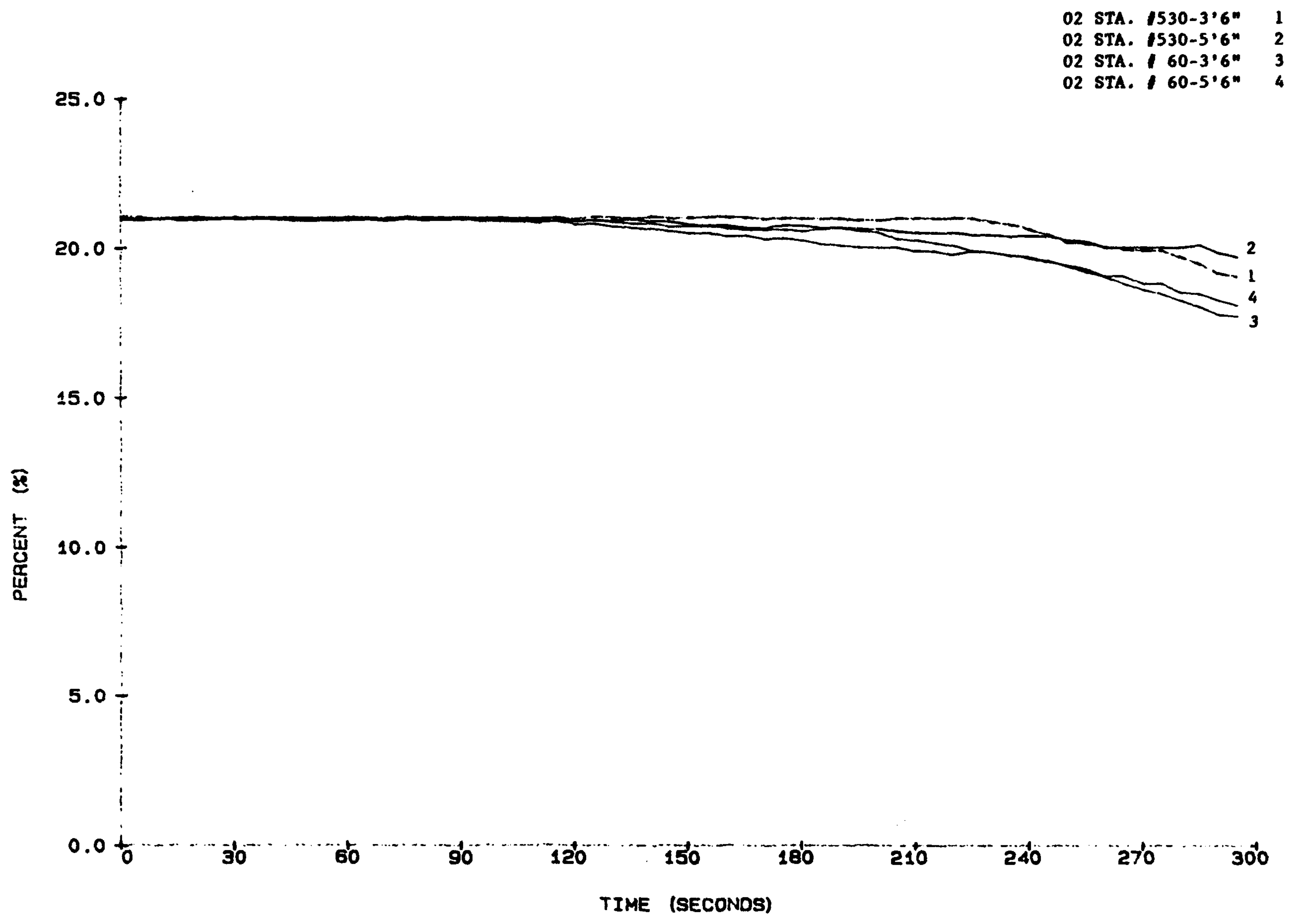

FIGURE 11. OXYGEN PROFILES - NEW MATERIAL

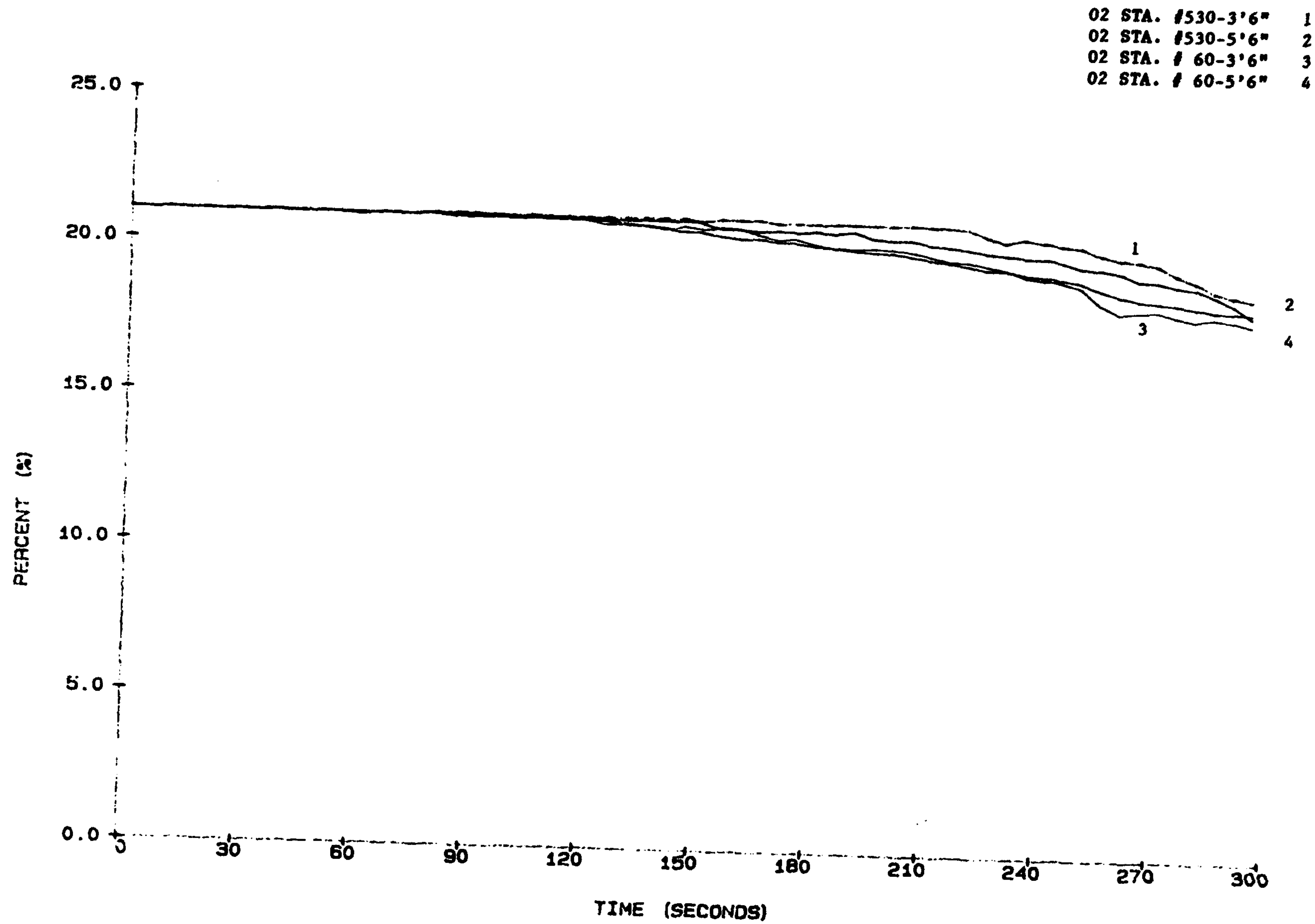

FIGURE 12. OXYGEN PROFILES - ABS/PVC

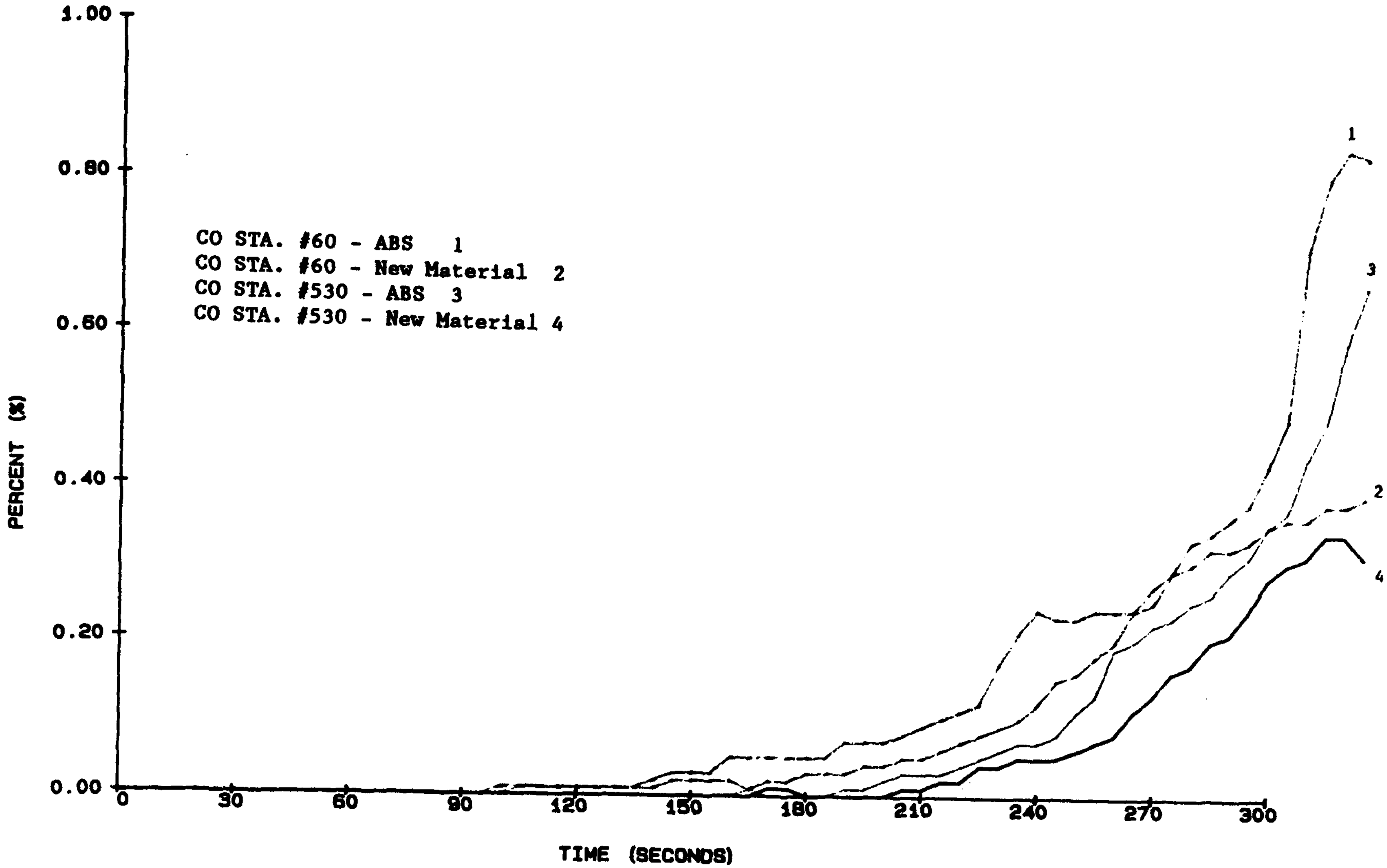

FIGURE 13. CARBON MONOXIDE 3'6"

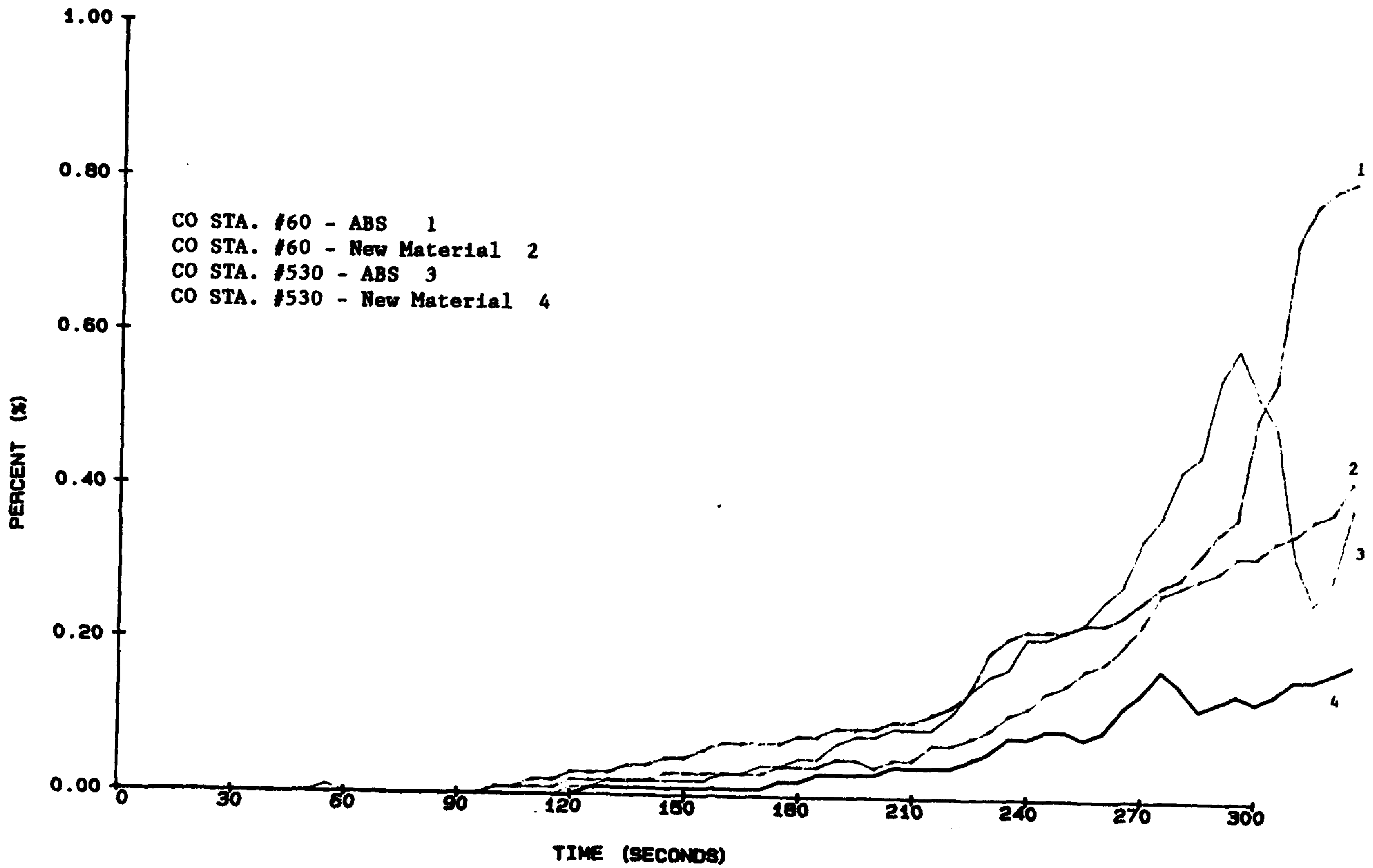

FIGURE 14. CARBON MONOXIDE 5'6"

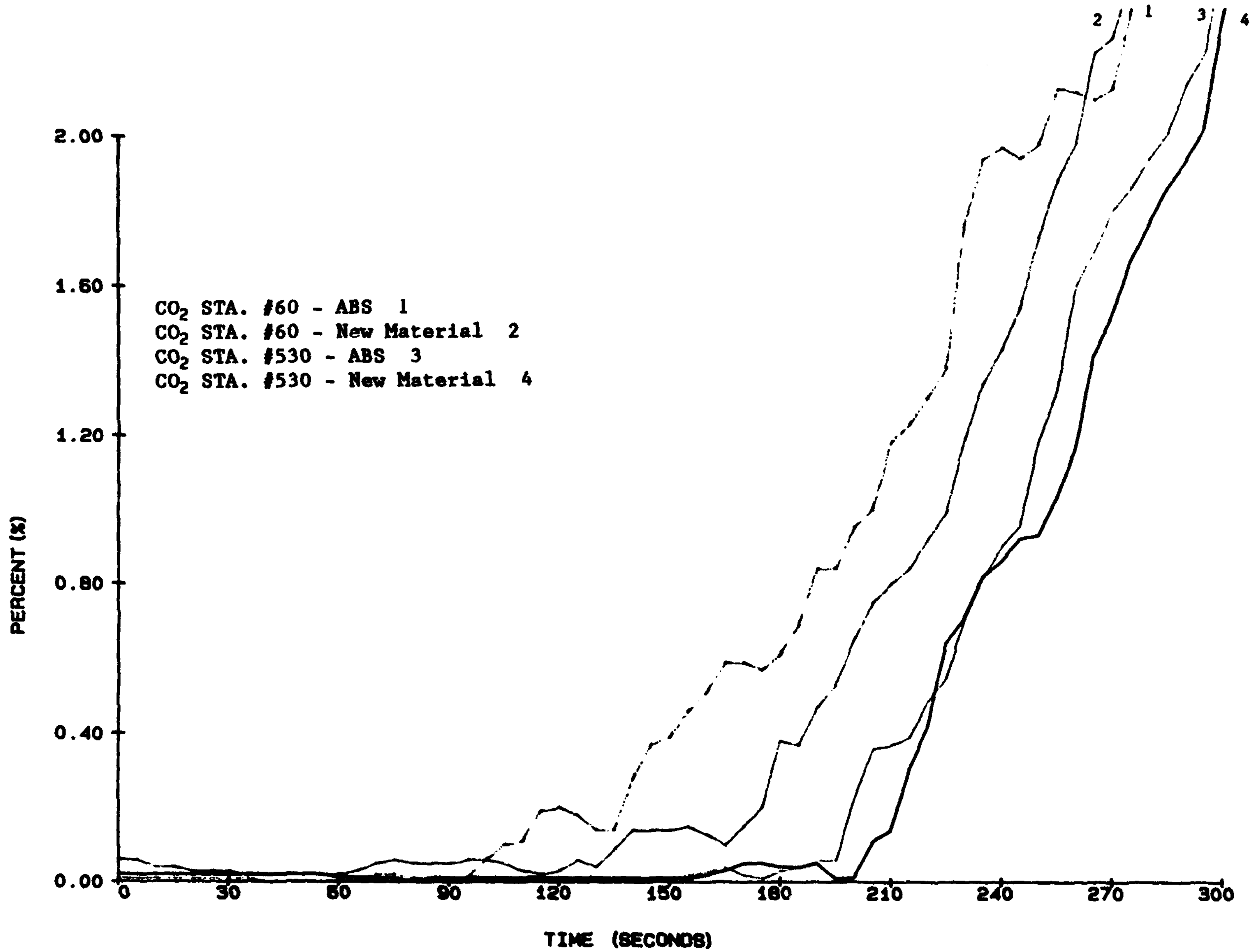

FIGURE 15. CARBON DIOXIDE 3'6"

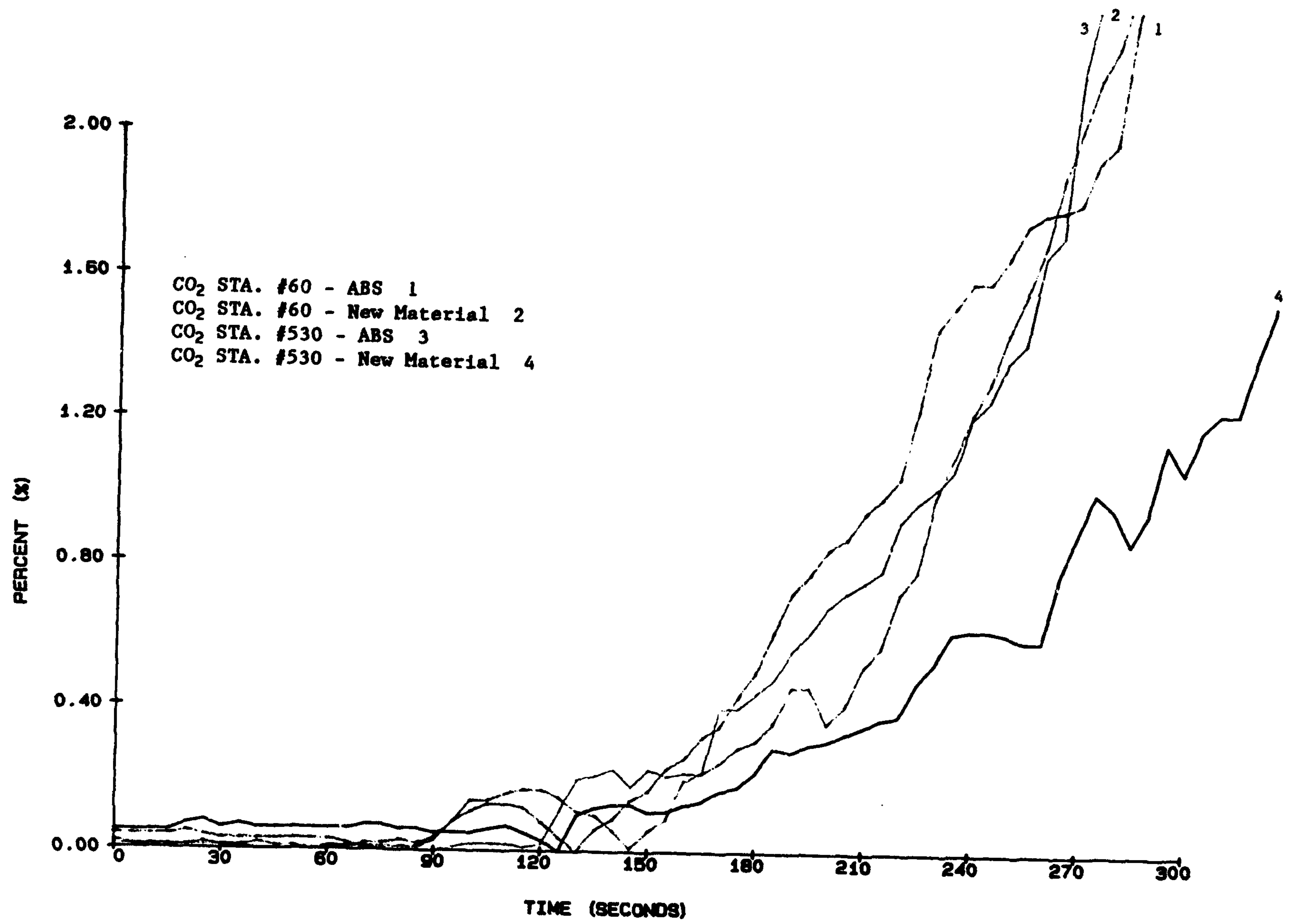

FIGURE 16. CARBON DIOXIDE 5'6"